UNION OF SOUTH AFRICA
UNIE VAN SUID-AFRIKA

DEPARTMENT OF MINES
DEPARTEMENT MYNWESE

GEOLOGICAL SURVEY
GEOLOGIESE OPNAME

MANGANIFEROUS IRON ORE, HEMATITE, BARITE, AND SILLIMANITE ON GAMS (PORTION I), NAMAQUALAND

BULLETIN 28

by

C. B. Coetzee

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MANGAANHOUDENDE YSTERERTS, HEMATIET, BARIET, EN SILLIMANIET OP GAMS (GEDEELTE I), NAMAKWALAND

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C. B. Coetzee, M.Sc., Ph.D.

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Geological map of ore-deposits on Gams (Portion 1).

MANGANIFEROUS IRON ORE, HEMATITE, BARITE, AND SILLIMANITE ON GAMS (PORTION I), NAMAQUALAND.

ABSTRACT.

Deposits of manganiferous iron ore, hematite, barite, and sillimanite occur in Kaaien metamorphics on the farm Gams (portion 1), 30 miles west of Pofadder, in the District of Namaqualand.

The bodies of iron ore and barite occur near the contact of quartzite and schist, along the slopes of a 200 foot deep kidney-shaped basin which was formed by the erosion of the central part of the Gamsberg. The ores are not admixed, but occur as separate lenses or tabular sheets, set in juxtaposition. The manganiferous ore is exposed intermittently along the strike for a distance of 26,000 feet. About 30 feet vertically below this ore, a barite sheet outcrops more or less continuously for 8,300 feet. Two small lenses of high-grade hematite occur on the horizon of the manganiferous ore. Two lenses of massive sillimanite are found lower down in the Kaaien metamorphics, some 7,000 feet to the southeast of the other ore-bodies.

The metamorphics float in an environment of granitic rocks. An epigenetic origin, followed by thermal metamorphism, is suggested for both the barite and the iron ore. The sillimanite originated by the recrystallisation of an aluminous sediment.

The reserves of barite to a depth of a hundred feet are estimated at 3,100,000 tons, but the remoteness of the site militates against exploitation under present conditions. The reserves in that sillimanite body which contains the better quality of material, are assessed at 2,000 tons to a depth of 10 feet.

I.—INTRODUCTION

During 1954 bodies of barite, iron ore, and sillimanite were discovered by Mr. R. G. Niemoller on the farm Gams (Portion 1). This farm, which lies in the Namaqualand District of the Cape Province, is situated on the main road between Springbok and Pofadder, some 30 miles to the west of the latter village.

The deposits were mapped on a scale of 1:25,000, and sampled by the author during September, 1955. Aerial photographs were not available, and surveying by plane-table in the central part of the Gamsberg proved difficult for two reasons, viz. the deposits occur in a recess in a peneplained mountain, and some of the ores are highly magnetic, so that orientation by compass becomes unreliable.

A petrographic examination of six specimens of the opaque ores was carried out by Mr. D. Groeneveld of the Geological Survey laboratory. Mr. R. G. Niemoller kindly submitted 32 chemical analyses of massive sillimanite which had been made for him during the evaluation and exploitation of some of the sillimanite deposits in this vicinity. Four of the analyses are listed in the text, and the others were considered in connection with the genesis of the aluminous ores.

II.—PHYSIOGRAPHY

A. CLIMATE AND WATER-SUPPLY

With reference to vegetation the area falls in a sector of the northwest Cape which is classified as a sand- and rock-desert.

A weak spring, which is said to flow constantly, arises near the foot of the Gamsberg on the eastern side. The best perennial source for large quantities of water is the Orange River, which, at the nearest place, on the farms Kambreek and Zandfontein, is approximately 30 miles north of Gams.

The following climatological figures for stations in the vicinity were supplied by the Weather Bureau, Pretoria.

Station.	Average annual precipitation (millimetres and inches)	Period of observation.
Goodhouse	54·6 mm. (2·15 ins.)	21 years
Pella	77·5 mm. (3·05 ins.)	71 years
Pofadder	98·6 mm. (3·88 ins.)	18 years.

Stations.	Average air temperatures (°C)	Period of observation.
Goodhouse	Daily maximum, 31·7	22 years.
Goodhouse	Daily minimum, 15·0	22 years.
Pofadder	Daily maximum, 26·1	17 years.
Pofadder	Daily minimum, 11·0	17 years.

B. MORPHOLOGY

A steep-sided mountain, the so-called Gamsberg, occupies the greater part of the farm Gams (Portion 1), and rises to an elevation of over 800 feet above the general level of the surrounding sandy plain. In plan he mountain is oval; it measures 4·9 miles in length, and 2·7 miles in width.

A sector of the hilltop forms the erosional relict of a former peneplain, whose extension elsewhere in the vicinity is indicated by similar altitudes of other table-mountains and peaks, which also show bevelling of folded Kaaien quartzite. The heights of a few trigonometrical beacons in such places are: Agenys I, 3,759 feet; Agenys II, 3,757 feet; Gams, 3,778 feet; Gams E, 3,741 feet; Tafel, 3,738 feet. Mabbutt ([8] *pp.* 13–15) calls this peneplain the Namaqua Highland, and assigns a Cretaceous age to it; he distinguishes it from the (lower) Bushmanland planation, which is set in the Tertiary.

The surface of the central part of the Gamsberg falls abruptly, and forms a basin with an approximately level floor, which is 200 to 250 feet below the level of the table-land. The basin is kidney-shaped and measures 13,500 feet by 5,500 feet across the central part. A number of watercourses coalesce inside the basin, and then drain northwards through a single deeply incised ravine. The latter has an extremely small breadth-height ratio, which is indicative of concentrated precipitation in an arid region.

III.—GENERAL GEOLOGY

A. The Host-Rocks

The host-rocks comprising the area may be divided into three lithological groups, viz.—

1. Recrystallised quartzite, quartz-sericite schist, and quartz-sillimanite schist.
2. Quartz-biotite schist, and amphibolite.
3. Aplogranite.

The first group includes rocks which are correlated with the Kaaien Series of the Kheis (or Swaziland) System. The recrystallised quartzite is light gray in colour, in places it is distinctly bedded or cross-bedded, and it carries sporadic pebbles (up to pigeon-egg size) of white quartzite. The quartzite band, which forms the peneplain of the Gamsberg and the cliffs around it, may be up to 700 feet thick, and is intricately folded. This major band is supplemented by thinner bands of similar quartzite, and by sillimanite-bearing quartzite, which occur lower down in the succession, i.e. within the second group. Sericite is invariably present in the quartzite, and when abundant, the rock becomes distinctly schistose, and assumes a silvery white or glittering appearance. A bed of brownish sillimanite-bearing quartzite occurs in places above the manganiferous iron ore, about 30 feet away from the latter.

The second group of rocks, i.e. the quartz-biotite schist, underlies the Kaaien quartzite, and is conformable with the latter. These rocks form the exterior slopes of the Gamsberg and the floor of the basin; their brownish or blackish colour contrasts conspicuously with the colour of the quartzite. Conglomerate bands and scattered cobbles occur within the quartz-biotite schist, and prove its sedimentary origin. Such outcrops can be observed at a number of places on the floor of the basin. The pebbles, which consist mostly of quartz and quartzite, have invariably been elongated, flattened, and drawn out during the metamorphism.

Aplogranite underlies the quartz-biotite schist, and is probably intrusive into it. The aplogranite on Gams may be correlated with the aplogranite in the Goodhouse-Pella area described by Coetzee ([4] *pp.* 181–189), and it resembles the pink gneiss from an area near Kakamas about 123 miles to the east of Gams, which is described by Poldervaart and von Backström ([11] *pp.* 455–470). Coetzee regarded the aplogranite as an acid differentiate of the Younger Namaqualand granite-gneiss. Poldervaart and von Backström, on the basis of very detailed research, contend that the pink gneiss is a reconstituted or granitised sediment. In chemical composition the aplogranite, and the pink gneiss, correspond to potash-soda granite; the following range for some of the radicals is known from four published analyses:—

SiO_2	73·24 to 77·27 per cent.
Al_2O_3	11·56 to 15·28 per cent.
Na_2O	2·03 to 3·18 per cent.
K_2O	5·16 to 5·54 per cent.

A few bodies of quartz-mica-feldspar pegmatite occur in the quartz-biotite schist, both inside and outside the basin.

B. Geological Structure

The general, or large-scale, structure of the Gamsberg conforms to a doubly plunging anticline, which exhibits subsidiary folding in its limbs. The latter folding is however local, since there is no indication of any duplication of the mineralised zone, so that the structure is not an anticlinorium.

The crest of the anticline would have been located above the present position of the basin. Since the crest was composed of competent quartzite, it was probably much fissured and fractured, and therefore less resistant to the agencies of weathering. Detritus was carried off from the crest, and eventually the present basin was formed in the soft core of the anticline.

IV.—ORE-DEPOSITS

Outcrops of manganiferous iron ore, iron ore, and barite occur at and near the contact of the recrystallised quartzite and the quartz-biotite schist, about a hundred feet above the floor of the basin. The trace of the contact is oval, its attitude is more or less horizontal, and the ores are exposed in the southern, eastern, and northern sectors.

The barite occurs some 30 feet vertically below the iron ore. Although the mineralised body is composite, the ores are not admixed on a megascopic scale, but occur in the form of separate lenses and tabular sheets which lie in juxtaposition. The ores dip into the mountain, and their extension in depth was never observed to follow the direction of the dip-slope of the basin.

Two lenses of massive sillimanite are found lower down in the Kaaien metamorphics, some 7,000 feet to the southeast of the barite and iron ore deposits.

A. The Manganiferous Iron Ore Deposit

1. DIMENSIONS, SECTIONS, AND SAMPLING OF ORE-BODIES

The deposit of manganiferous iron ore occurs as separate bodies, which, at localities 1, 5, 7, 8, and 9, are continuous or nearly continuous (cf. folder). Between these bodies, evidence of mineralisation near the inferred position of the lithological contact is shown by the widespread occurrence of ferruginisation products, especially along the southern and eastern sectors, and to a minor extent also along the northern sector. It is possible therefore, that along the lines of ferruginisation, additional ore-bodies may occur under cover of talus. The scarcity of ferruginisation products along the western sector, and the absence of ore-bodies where the deeply incised northerly drainage from the basin cuts across the contact, suggest that the iron-manganese mineralisation is patchy. The total length of this intermittent mineralisation along the strike, between localities 1 and 10, is 26,000 feet.

Groove samples, each about 8 pounds in weight, were taken across the ore-bodies at localities 1, 5, 7, 8, 9, and 10, in places where the full widths of the bodies are exposed. Details of the size of the individual bodies, their dip, and the nature of the hanging-wall and the foot-wall are appended below. The thicknesses are true widths, and have been derived by applying corrections (for the dip of the ore, and the slope of the ground) to the width across which a sample or parting was measured on the surface. In any sample-section, the sample with the smaller number refers to the lower part of the ore, and the sample with the bigger number refers to the upper part of the ore.

Locality 1

The ore-body is 227 feet long, the direction of strike is north 45 degrees west, and the dip is 40 degrees to the southwest. The profile across the body, where the greatest thickness is exposed, is as follows:—

Thickness		Formation and nature of walls	Sample numbers
Ft.	In.		
		Hanging-wall: quartzite	
7	10	Manganiferous iron ore........................	CC 326, CC 327
		Foot-wall: quartzite	

The corrected width of each sample is 3 feet 11 inches.

Locality 5

The ore-body is about 2,300 feet long, and dips to the east and north-east at 50 degrees and 48 degrees respectively. It is best exposed in the deep ravine where the profile across the mineralised zone (including the barite) and the associated rocks is as follows:—

Thickness		Formation and nature of walls	Sample numbers
Ft.	In.		
		Hanging-wall: quartzite	
13	0	Manganiferous iron ore........................	CC 315, CC 316, CC 317.
15	10	White quartzite	
31	6	Ferruginous quartzite	
36	1	Amphobilite	
12	9	Ferruginous quartzite	
5	7	Barite	
14	8	Blackish quartzite	
92	8	Micaceous schist	

The corrected width of each sample is 4 feet 4 inches.

Locality 7

The ore-body is exposed over a length of about 350 feet, and grades westwards as far as can be ascertained into ferrugionous quartzite, which dips to the north at 35 degrees. The most robust portion of the ore exposure is 300 feet from the eastern end, where a section across the body is as follows:—

Thickness		Formation and nature of walls	Sample numbers
Ft.	In.		
		Hanging-wall: quartzite	
11	6	Manganiferous iron ore........................	CC 309, CC 310, CC 311.
		Foot-wall: usually schist, quartzite in places	

The corrected width of each sample is 3 feet 10 inches.

Locality 8

The ore-body is about 800 feet in length, and consists of lenses of ore in a bed of ferruginous quartzite, which attains a vertical thickness of 106 feet. The ferruginous quartzite dips to the east and northeast at 51 degrees, and it is overlain and underlain by micaceous schist. Just west of the ravine, where the greatest thickness of ore is exposed, a profile across it is as follows:—

Thickness		Formation and nature of walls	Sample numbers
Ft.	In.		
		Hanging-wall ferruginous quartzite	
4	9	Manganiferous iron ore	CC 307
42	7	Ferruginous quartzite	
2	4	Manganiferous iron ore	CC 306
5	4	Ferruginous quartzite	
1	5	Manganiferous iron ore	CC 305
		Foot-wall: ferruginous quartzite	

In the ravine, and along the steep slopes of the hill to the east of the ravine, one or two of the lenses listed above, peter out. To the west of the sampled section, the quality of the ore deteriorates, and beyond its western boundary the body grades into poorly mineralised quartzite and ferruginisation products which continue to a point close to the ravine at locality 9.

Locality 9

The ore-body is about 150 feet in length. It consists of disseminated ore in schistose rock, and dips to the north at 60 degrees. On the west side of the ravine, where the greatest thickness of the ore is exposed, the section across the body is as follows:—

Thickness		Formation and nature of walls	Sample numbers
Ft.	In.		
		Hanging-wall: quartzite	
1	5	Manganiferous iron ore	CC 303
1	11	Schistose partings	
1	0	Manganiferous iron ore	CC 302
		Foot-wall: micaceous schist	

Locality 10

At this locality conspicuous outcrops of ferruginous quartzite extend for about 900 feet on the north side of the ravine, and about 1,300 feet on the south side. Very little ore could actually be found in the quartzite, and a typical profile is as follows:—

Thickness		Formation and nature of walls	Sample numbers
Ft.	In.		
		Hanging-wall: quartzite	
¼ inch to 3 inches		Stringers of manganiferous iron ore	CC 301
		Foot-wall: usually schist, quartzite in places	

The mineralisation clearly occurs in the nose of a dissected anticlina fold in the quartzite.

2. MINERALOGY OF THE ORE.

(*a*) *The Ore Minerals*

Mr. D. Groeneveld of the Geological Survey laboratory, identified the opaque minerals in six specimens of manganiferous iron ore, and determined the approximate modes in polished and thin sections by means of a Swift Automatic Point Counter. In every specimen, one or more of the opaque minerals which are listed below with their formulae, were identified.

Jacobsite, $MgO.Fe_2O_3.(Mn,Fe)O.Fe_2O_3$

Cryptomelane, a manganese oxide containing potassium, and 2 to 4 per cent. non-essential water (7 *p.* 273)

Bixbyite, $(Mn,Fe)_2O_3$

Psilomelane, a manganese oxide containing varying amounts of barium, and essential water

Pyrolusite, MnO_2 with about 2 per cent. water

Hematite, Fe_2O_3

The mineralogy of the specimens examined, is described briefly below

Specimen CC 302

The ore is crudely banded and consists of red earthy hematite with veins of cryptomelane. The hematite is well crystallised, and may be surrounded by cryptomelane which has apparently crystallised later. As in the case of specimen CC 326, the cryptomelane may be secondary. The gangue consists of quartz and sericite; the latter is probably an alteration product of feldspar.

The mode is approximately as follows:

Cryptomelane	30 per cent.
Hematite	25 per cent.
Quartz	40 per cent.
Sericite	5 per cent.

Specimen CC 305

The ore consists predominantly of hematite and subordinate amounts of bixbyite and cryptomelane, both of which are interstitial. The specimen is slightly banded, and ore-rich layers alternate with garnet gangue. The ore exhibits feeble folding, which is probably post-mineralisation in age.

The mode is approximately as follows:—

Bixbyite	15 per cent.
Psilomelane	5 per cent.
Hematite	50 per cent.
Garnet	30 per cent.

Specimen CC 306

Bixbyite and hematite are more or less intimately associated, and the bixbyite tends to be interstitial to hematite. The gangue, which is mostly garnet, comprises about 5 per cent. of the constituents. The mode is approximately as follows:—

Psilomelane and bixbyite	57 per cent.
Hematite	38 per cent.
Garnet	5 per cent.

Specimen CC 310

The ore consists of hematite with a few individual bixbyite crystals. Under high magnification the hematite appears to be finely intergrown with bixbyite. This explains the comparatively high manganese content of the sample (29·16 per cent MnO_2).

It is possible that the bixbyite has been replaced by hematite, in which case the bixbyite grains may be regarded as unreplaced remnants. Uytenbogaardt (13 *p*. 181) suggests that bixbyite may alter to an intergrowth of hematite and braunite. Since the X-ray patterns of this material shows only the stronger hematite lines, the manganese mineral could not be conclusively identified. However from the appearance and apparent isotropism of the manganese mineral, it seems more likely that there is an intergrowth of hematite and bixbyite, and that braunite is not present.

The mode is approximately as follows:—

Hematite and bixbyite	65 per cent.
Garnet	35 per cent.

Specimen CC 315

The ore minerals jacobsite and hematite were identified; the gangue comprises pyroxene, plagioclase and garnet. The ore-minerals are subhedral, and the texture is usually granoblastic; they are mutually accomodated, and no replacement textures were noticed. The gangue minerals are interstitial to the ore in some cases, and often surround crystals of hematite and jacobsite: this suggests that gangue formation was later than ore-mineralisation.

The mode is approximately as follows:—

Jacobsite	40 per cent.
Hematite	20 per cent.
Pyroxene, feldspar, garnet	40 per cent.

Specimen CC 326

Jacobsite and cryptomelane are the predominant minerals, and occur separately or as an intergrowth. In the latter case cryptomelane forms roughly parallel laminations in the jacobsite, the lamellae being optically continuous with the ground-mass cryptomelane. A few secondary pyrolusite stringers intersect both jacobsite and cryptomelane.

The intergrowths may be the result of unmixing during crystallisation, or the cryptomelane may be an alteration product of hausmannite. The association of jacobsite and hausmannite is quite common in manganese ores, and the intergrowth of the two minerals constitutes the so-called vredenburgite. In the ores from the Otjosondu area, de Villiers ([6] *p.* 93) suggests that hausmannite lamellae altered to psilomelane during weathering.

The mode is approximately as follows:—

Jacobsite	48 per cent.
Cryptomelane	48 per cent.
Pyrolusite	3 per cent.
Gangue	1 per cent.

(*b*) *The Gangue Minerals*

The gangue in the ore from locality 5 consists of the following minerals in order of abundance: orthopyroxene, clinopyroxene, garnet, quartz, and microcline.

The *orthopyroxene* belongs to the eulite group. The following properties were determined:—

$n\alpha=1{\cdot}749\ (\pm0{\cdot}004)$

$n\gamma=1{\cdot}778\ (\pm0{\cdot}004)$

X=brown

Y=brown

Z=golden brown

The *clinopyroxene* is an augite. The following properties were determined:—

$n\alpha=1{\cdot}707\ (\pm0{\cdot}004)$

$n\gamma=1{\cdot}721\ (\pm0{\cdot}004)$

X=Y=Z=whitish

The *garnet* has a yellowish-green colour, and a refractive index of 1·907 (±0·007). It therefore contains more than 50 per cent of the andradite molecule.

Vugs filled with cryptocrystalline silica into which radiating needles of the surrounding opaque minerals project occur in some specimens, especially in those from locality 1. The largest vug observed measures 1·9 millimetres in length.

3. CHEMICAL ANALYSES OF ORE IN SITU

The chemical analyses of samples of the manganiferous iron ore, from the localities described in section AI, are listed in table No. I, together with the corrected sample widths.

TABLE NO. 1.—CHEMICAL ANALYSES OF MANGANIFEROUS IRON ORE IN SITU

	Locality 1		Locality 5			Locality 7			Locality 8			Locality 9		Locality 10
	CC 326	CC 327	CC 315	CC 316	CC 317	CC 309	CC 310	CC 311	CC 305	CC 306	CC 307	CC 302	CC 303	CC 301
SiO_2..........	18·58	9·61	10·46	8·28	11·82	8·50	15·58	9·44	19·61	10·30	15·24	28·22	13·52	22·18
Al_2O_5........	2·61	3·33	5·30	3·15	2·55	3·89	0·28	9·67	4·29	5·74	4·19	3·06	2·98	4·46
Fe_2O_3........	34·88	47·24	67·30	64·68	59·64	51·42	49·31	52·32	49·57	49·38	35·94	34·17	58·30	33·44
MnO..........	19·20	17·01	*	13·47	*	*	*	*	11·05	*	*	*	3·45	*
MnO_2........	18·09	17·75	12·65	6·70	22·28	29·78	29·16	22·67	3·13	25·00	34·60	25·59	15·65	35·04
TiO_2.........	0·16	0·39	0·43	0·30	0·29	0·31	0·30	0·28	0·41	0·53	0·34	0·46	0·46	0·20
P_2O_5.........	0·35	0·44	0·55	0·05	0·40	0·06	0·07	0·05	1·41	1·07	1·17	1·11	0·76	0·14
BaO..........	0·97	0·35	1·60	0·43	0·32	0·06	1·33	1·22	0·96	2·22	2·45	2·39	1·65	0·03
SO_3..........	0·40	0·19	0·32	0·49	0·14	1·11	0·62	0·57	0·23	0·17	0·09	0·07	0·06	0·04
K_2O..........	1·00	0·80	1·20	0·50	0·60	0·70	0·50	0·60	0·40	2·10	0·90	0·70	0·90	1·20
H_2O..........	0·19	0·31	0·14	0·08	0·06	0·48	0·50	0·43	0·57	0·44	0·84	0·76	0·24	0·55
H_2O+........	3·35	2·91	0·30	1·86	2·16	3·38	2·85	3·13	3·15	2·88	4·12	3·84	2·56	2·19
Total.......	99·78	100·33	99·75	100·49	100·26	100·23	100·50	100·38	100·26†	99·83	99·88	100·37	100·53	100·47
Width in inches	47	47	52	52	52	46	46	46	17	28	57	12	17	3

* All manganese determined as MnO_2.

† Includes 5·48 per cent. CaO.

Analysts: C. E. G. Schutte, C. Lessing, and A. J. Rossouw,
Division of Chemical Services, Pretoria.

4. CHEMICAL ANALYSES OF FLOAT-ORE

Since the ore-bodies outcrop intermittently, two samples of float-ore from positions intermediate between some of the exposed bodies were analysed, in order to ascertain the nature of some of the ore which is undoubtedly concealed by rubble.

Sample CC 325 was obtained from a large lump of float-ore found 35 feet to the west of locality 2; the analysis indicates that the contents of manganese and iron are similar to the value found in the samples from the bodies at localities 1 and 5. Sample CC 312 is a specimen of float which may be derived from concealed ore which possibly occurs 3 to 5 feet below, and to the west of, the ore-body at locality 7; the analysis indicates that the material is ferruginous quartzite.

The chemical analyses of the samples of float-ore are listed in table No. 2.

TABLE NO. 2.—CHEMICAL ANALYSES OF MANGANIFEROUS IRON ORE FLOAT

	CC 325	CC 312
SiO_2	10·59	61·40
Al_2O_3	2·54	0·10
Fe_2O_3	60·88	20·36
MnO	18·39	*
MnO_2	4·87	13·73
TiO_2	0·00	0·22
P_2O_5	0·46	0·04
BaO	0·45	0·57
SO_3	0·22	1·49
K_2O	0·30	0·30
H_2O-	0·07	0·15
H_2O+	1·29	2·43
Total	100·06	100·79

*All manganese determined as MnO_2

Analysts: C. E. G. Schutte, C. Lessing, and A. J. Rossouw,
Division of Chemical Services, Pretoria

B. THE HEMATITE DEPOSIT

1. DIMENSIONS AND SAMPLING OF ORE-BODIES

Two hematite exposures occur along the zone of mineralisation, namely at localities 1 and 6. Some specimens of the ore are magnetic, probably from admixed magnetite.

Locality 1

The northern of the two ore-bodies shown at this position consists of a hematite lens which is about 100 feet long, and 15 feet thick at the centre. The hanging-wall and the foot-wall consist of quartzite. The lens apparently dips to the southwest, and it is probably transgressive.

A groove sample, CC 328, was taken across the full width, near the centre of the body.

Locality 6

This hematite lens is about 200 feet long and 16 feet thick at the centre. At the northern and southern ends of the body the ore grades into ferruginous quartzite, and partings of quartzite also occur within it. The lens dips to the east at 41 degrees; the hanging-wall consists of quartzite, and the foot-wall of amphibolite.

Sample CC 313 is from the central part, where the body is homogeneous and composed of iron ore only.

2. CHEMICAL ANALYSES OF THE HEMATITE

The chemical analyses of the samples from the hematite bodies are listed in table No. 3.

TABLE NO. 3.—CHEMICAL ANALYSES OF HEMATITE

	Locality 1 C 328	Locality 6 CC 313
SiO_2	2·69	0·88
Al_2O_3	0·83	0·52
Fe_2O_3	92·68	94·35
MnO	*	*
MnO_2	0·24	0·24
TiO_2	0·52	0·52
P_2O_5	0·49	0·05
BaO	0·38	0·95
SO_3	0·51	1·02
K_2O	0·10	0·20
H_2O-	0·00	0·12
H_2O+	1·94	1·01
Total	100·38	99·86

*All manganese determined as MnO_2

Analysts: C. E. G. Schutte, C. Lessing, and A. J. Rossouw,
Division of Chemical Services, Pretoria.

C. THE BARITE DEPOSIT

1. FIELD CHARACTERS OF BARITE DEPOSIT

The barite sheet crops out amidst scree at numerous places between locality 1 and a position 1,100 feet to the north of the water-course at locality 5; elsewhere in the basin outcrops of barite were not seen. The body can seldom be observed across its full width, but the abundance and the thickness of the exposures suggest that the barite sheet is much more continuous than the bodies of iron ore which trend parallel to it. The observed length of strike is 8,300 feet, and the dip is away from the basin at angles varying from 30 to 50 degrees.

The colours of the barite in order of relative abundance are gray, pink, reddish, and white. The cleaner (white) barite occurs as distinct bands, or as pockets in the other types, but in places it is intermingled with them. The barite is traversed by numerous cracks and joints, along which there is often a reddish stain varying from less than 1 millimetre to more than 0·5 inch in width; frequently the discoloration is attended by a concentration of iron-bearing minerals.

The barite body is parted in places by lenses of quartzite which are continuous along the strike for a number of yards, and it also carries inclusions of quartzite less than 3 feet in length.

Profiles across the barite are appended below.

Locality 4

Thickness Ft.	Thickness In.	Formation and nature of walls	Sample numbers
		Hanging-wall: quartzite	
3	0	Reddish (ferruginous) barite	CC 322
5	0	Whitish barite	CC 324
1	10	Reddish (ferruginous) barite	CC 322
1	6	Ferruginous quartzite	
5	10	Reddish (ferruginous) barite with quartzite inclusions	CC 322
23	11	Gray barite	CC 321
		Foot-wall: micaceous quartzite with schist lenses	

A section of the barite body in the ravine opposite locality 4 is shown above together with the corrected widths of the partings, and the numbers of the groove samples. The barite sheet dips to the south at 31 degrees.

Locality 5

In the ravine at locality 5 the barite body is only 5 feet 7 inches thick (cf. page 8), but this thinning is undoubtedly local. About 250 feet to the southwest of this ravine the barite is about 25 feet thick, and about 900 feet to the north of the ravine (i.e. near the northern end of the exposure) the thickness is also 25 feet. A section across the barite body in the latter position is as follows:—

Thickness Ft.	Thickness In.	Formation and nature of walls
		Hanging-wall: blackish quartzite
6	6	Barite with quartzite parting 2 inches to 4 inches in width
3	0	Schist
2	6	Ferruginous quartzite
18	6	Reddish (ferruginous) barite
		Foot-wall: schist

The schist parting dips to the northeast at 70 degrees

2. SAMPLING OF BARITE BODY

Three groove samples, CC 321, CC 322 and CC 324 (indicated above) were taken across the barite body at locality 4: number CC 322 is a composite sample of the three bands of ferruginous barite. In addition, three samples of white, light gray, and pink barite were obtained from three prospecting-pits which had been newly made at the time. The latter samples (CC 318, CC 319, and CC 320) are from pits which are located approximately 250 feet, 500 feet, and 650 feet respectively along the barite band, on the south side of the ravine at locality 5.

3. MINERALOGY OF THE ORE

Typical specimens of the massive barite are of medium grain, i.e. most of the crystals are between 1 and 5 millimetres in maximum diameter. In thin sections the barite commonly shows twinning and undulose extinction.

In a sample which assayed 98·27 per cent $BaSO_4$, grains of iron ore occur consistently within the barite crystals, and they are not preferentially disposed along boundaries between the barite crystals, or near cracks in the latter. The maximum diameters of the grains of iron ore are usually less than 0·24 millimetre, but smaller idioblasts which average 0·07 millimetre in maximum diameter are relatively more abundant than the larger grains.

In a specimen which consists of similar volumes of quartz, barite, and iron ore (hematite), the distribution of the last-named is not confined to the interior portions of the barite crystals. The iron ore crystals, which range from 1·46 millimetre by 0·95 millimetre downwards in size, also occur between quartz crystals, and between crystals of quartz and barite. In one portion of the section, a train of barite and iron ore crystals occurs around the periphery of a large quartz individual which exhibits pronounced strain shadows. Sieve textures involving hematite and barite occur in a few of the large crystals, and the former mineral constitutes the host.

4. CHEMICAL ANALYSES OF THE BARITE

The chemical analyses of samples from the barite body are listed in table No. 4.

TABLE NO. 4.—CHEMICAL ANALYSES OF THE BARITE

	CC 321	CC 322	CC 324	CC 318	CC 319	CC 320
$BaSO_4$..........	93·36	85·18	95·47	91·10	98·27	96·54
Fe_2O_3..........	2·40	8·47	0·64	0·96	0·64	1·76
SiO_2..........	3·60	5·59	3·85	8·25	1·48	1·09
$CaSO_4$..........	0·10	1·02	Trace	0·10	0·10	0·20
MnO_2..........	0·04	0·16	0·01	0·04	0·04	0·03
Total........	99·50	100·42	99·97	100·45	100·53	99·62
Corrected with (feet).........	23·9	10·6	5·0	—	—	—
Specific gravity.	4·45	4·14	4·06	4·27	4·30	4·53
Colour.........	gray	reddish	white	white	gray	pink

Analysts: C. E. G. Schutte, C. Lessing, and A. J. Rossouw,
Division of Chemical Services, Pretoria.

D. THE SILLIMANITE DEPOSITS

1. FIELD CHARACTERS OF SILLIMANITE DEPOSITS

Two outcrops of massive sillimanite occur near the southern corner of the farm, in positions located 1,200 feet and 1,500 feet respectively to the north of the Springbok-Pofadder road. The deposits are found on either side of a quartzite koppie, which is about 100 feet high.

The northern occurrence is intermittently exposed along a strike of 640 feet; it exhibits pronounced pinch-and-swell structure, and has an average width of about 18 inches. The body occurs within brown micaceous schist at a distance of 100 to 150 feet away from the quartzite, and it dips to the south at an angle which varies from place to place. The sillimanite is soft, friable, and of a dirty brownish colour.

The southern occurrence is probably of lenticular form: it is about 100 feet long, and apparently 30 feet thick near the centre. Large blocks of sillimanite which have slumped from the outcrop, are strewn along the steep slope on the south side of the hill, and obscure the field relations as well as the thickness of the deposit. If the body dips (steeply) to the south, then the foot-wall is schistose quartzite, and the hanging-wall brown micaceous schist. The schistose quartzite forms a band 5 feet thick, and occurs between the sillimanite and the quartzite.

The sillimanite is hard, and white to light gray in colour. In thin sections, ilmenite grains with an average diameter of 0·24 millimetre are fairly abundant, and reddish brown rutile crystals occur occasionally.

2. OTHER DEPOSITS OF SILLIMANITE IN THIS VICINITY

It should be noted that these are not the only occurrences of sillimanite in the neighbourhood of Pella. Twenty miles to the northwest of the lenses described above, on the farms Wortel (Portion 1) and Koenabib, five occurrences of sillimanite are known*: they lie nearly in a straight line, 14,300 feet in length. All the deposits occur in micacoeus schist, and their stratigraphical position is not far below a thick band of Kaaien quartzite. At another deposit, also on Wortel, but to the south of the aforementioned row, the associated rocks are similar. Development at some of these occurrences has indicated that the sillimanite bodies are highly lenticular, along both the strike and the dip.

An inselberg of sillimanite rock, 145 feet long and 40 feet wide, projects above the sand on Gams (portion 2), at a position 1·9 miles northeast of the Tafel trigonometrical beacon.

The sillimanite-corundum deposits on the farm Pella have been described by Coetzee ([3] *pp.* 199–205) and Wiid ([14] *pp.* 1–20).

3. MINERALOGICAL AND CHEMICAL COMPOSITION OF THE SILLIMANITE ORES

Chemical analyses of sillimanite ores from Gams are listed in table No. 5, together with comparative analyses of sillimanite from Wortel and Koenabib.

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*Towards the end of 1955, Mr. R. G. Niemoller was producing about 200 tons of sillimanite per month from the deposits on Wortel and Koenabib.

A feature of these analyses, as well as of many others prepared for Mr. Niemoller, is that the percentage of TiO_2 usually exceeds, or is only slightly less than, the percentage of Fe_2O_3. The TiO_2 could therefore combine with all the iron to form ilmenite, and any excess of TiO_2 may appear in the form of rutile. This relation also applies to most of the analyses of the sillimanite-corundum rock, which are listed by Wiid ([24] *pp.* 4–6). In 46 out of 54 analyses which are available of the different types of aluminous deposits from the neigbourhood of Pella, the TiO_2 could " satisfy " iron, or leave an excess of rutile.

Many of the analyses of sillimanite show a comparatively high percentage of total water: this may be due to the presence of boëhmite ($Al_2O_3.H_2O$). The latter, as well as kaolinite, were indentified by the British Ceramic Research Association in samples V and VI, by means of X-ray examination.

TABLE NO. 5.—CHEMICAL ANALYSES OF SILLIMANITE ORE FROM GAMS, WORTEL, AND KOENABIB.

	I	II	III	IV	V	VI	VII
SiO_2	35·65	33·82	37·44	35·99	34·99	33·27	34·28
Al_2O_3	55·61	58·78	56·18	58·09	61·98	59·38	58·99
Fe_2O_3	2·72	1·12	2·03	0·80	0·27	0·21	0·33
TiO_2	2·73	3·11	2·01	1·99	1·20	0·63	0·76
P_2O_5	0·34	0·39	—	0·12	—	—	—
MgO	0·39	0·32	—	0·50	0·22	0·28	0·32
CaO	0·44	0·70	—	0·35	0·38	0·31	0·26
K_2O	0·43	0·34	—	0·94	0·14	0·07	0·39
Na_2O	—	—	—	—	0·11	0·06	0·21
H_2O-	0·20	0·10	—	0·08	—	—	—
H_2O+	1·11	1·78	1·72*	1·42	0·65*	5·78*	4·24*
Total	99·62	100·46	99·38	100·28	99·87	99·99	99·78

*Loss on ignition —Not determined

I. Specimen of soft brownish sillimanite, northern occurrence, Gams (portion 1).
II. Specimen of hard sillimanite, southern occurrence, Gams (portion 1).
III. Sample of sillmanite, Gams (Portion 2).
IV. Specimen of hard sillimanite, deposit No. 7, Koenabib.
V. Bulk sample of sillimanite ore, deposit No. 7, Koenabib.
VI. Bulk sample of sillimanite ore, deposit No. 6, Koenabib.
VII. Bulk sample of sillimanite ore, deposit No. 1, Wortel.

Analysts: I, II, IV, C. E. G. Schutte, C. Lessing, and A. J. Rossouw, Division of Chemical Services, Pretoria.
III. Standard Bank of South Africa, Limited. Analysis kindly supplied by Mr. R. G. Niemoller.
V, VI, VII. The British Ceramic Research Association, Stoke-on-Trent. Analyses kindly submitted by Mr. R. G. Niemoller.

E. ORIGIN OF THE DEPOSITS

The genesis of the deposits on Gams must be considered in conjunction with the data obtained by Mathias ([9]), Coetzee ([3]), and Wiid ([14]) during the investigation of similar deposits in this vicinity.

1. THE DEPOSITS OF BARITE AND IRON ORE

(*a*) *Barite and Iron Ore on Zuurwater*

Mathias ([9] *pp.* 208–217) describes the occurrence of barite in an iron ore deposit on the farm Zuurwater, 10 miles west-northwest of the deposits in the Gamsberg. The iron ore (hematite and remnantry magnetite), probably occurs on two horizons. The northern outcrops occur in Kaaien quartzite which is underlain and overlain by schist, which in turn is followed upwards by thick beds of Kaaien quartzite. Another series of outcrops, 3,200 yards farther south, also occur in Kaaien quartzite which is overlain and underlain by schist. The bodies of quartzite, schist, and ore dip to the the north-northeast at 22 degrees to 37 degrees, and are separated from one another by intermittent outcrops of granite.

In a sector of the southern outcrops of iron ore, barite occurs as a gangue mineral in addition to quartz. The body of barite and iron ore is is approximately 6 feet wide, and the chemical analysis of a hand-specimen corresponded to the following mineralogical composition:—

Quartz	41·3 per cent.
Barite	18·1 per cent.
Ilmenite	0·3 per cent.
Magnetite	2·5 per cent.
Hematite	30·6 per cent.
Limonite	6·6 per cent.
Total	99·4 per cent.

From the field relations and the petrography, Mathias postulates an epigenetic origin for both the barite and the iron ore. The latter is regarded as a metasomatic replacement deposit introduced into the quartzite from an igneous source (granite), and the barite is regarded as a later phase of hydrothermal emanation from the same source.

(*b*) *Barite and Iron Ore on Gams*

The origin of the barite and iron ore is assumed to be similar for the following reasons:—

(i) The juxtaposition of the ore-bodies.

(ii) Barium occurs in significant amounts in the iron ore. In 17 analyses the percentage of BaO varies from 0·3 per cent. to 2·4 per cent., and in only one analysis (of ore far away from any known barite occurrence) is the amount of BaO insignificant (0·03 per cent).

(iii) Ferric oxide occurs consistently in the barite in quantities varying from 0·6 per cent. to more than 8 per cent. An epigenetic origin for both the barite and the iron ore is indicated by the following considerations:—

(i) If a syngenetic origin is assumed, and the deposits on Zuurwater and Gams are correlated, the thickness of rocks which intervene between the barite and the iron ore horizons is much greater at the former locality (viz. several thousand yards), than at the latter locality (viz. less than a hundred feet).

(ii) The ores occur in an anticlinal structure. Provided this is of the requisite age, relatively favourable loci for ore deposition would have existed in and near the crest. Passageways could have been provided by bedding planes at the contact of the quartzite and the schist, as well as by fractures produced during the folding of the quartzite.

(iii) The iron ore does not occupy the same stratigraphic horizon everywhere. In the southern and eastern portions of the basin the foot-wall is composed of quartzite, but in the northeastern and northern portions the foot-wall is composed of schist, with quartzite in places only. This may be interpreted as transgression.

(iv) The hematite body at locality 1 apparently transgresses the quartzite. It also assumes the shape of a stout lens, and does not taper gradually as might be expected if it were originally a placer deposit.

(v) In addition to partings of quartzite which are continuous along the strike for a number of yards, the barite carries inclusions of quartzite, less than 3 feet in length.

(vi) The fabric of the quartz-barite-hematite rock is consistent with the introduction into quartzite first of iron-bearing minerals, and later of barite.

(vii) Vugs filled with cryptocrystalline silica occur in the manganiferous iron ore. They indicate deposition from solution ([5] *p.* 379), but whether such deposition refers to a primary vein or to secondary enrichment is uncertain.

An important point in regard to the probable genesis of the existing minerals is that the deposit has been subjected to, and extensively altered by thermal metamorphic effects. Orthopyroxene and andradite garnet occur in high-grade metamorphosed magnesian rocks, and in metamorphosed calcareous rocks respectively. Hausmannite, jacobsite, and bixbyite are high-temperature minerals, and are therefore the product of thermal metamorphism or hydrothermal replacement.

The deposit is geologically old, as even the metamorphic manganese minerals have been altered by weathering, e.g. hausmannite to cryptomelane.

2. THE SILLIMANITE DEPOSIT

Coetzee ([3] *pp.* 201–204) referred the origin of the sillimanite-corundum rock on the farm Pella to the recrystallisation of a dominantly aluminous sediment (bauxite), without the addition of a significant amount of igneous material. That conclusion was based on one chemical analysis, and the texture of the rock.

A similar origin is also suggested for the practically pure sillimanite bodies, and it is supported by the apppreciable amount of TiO_2, which appears consistently in the large number of chemical analyses which have now been made of the aluminous rocks. According to Ramkama and Sahama ([12]*p.* 563) the laterites, which may contain as much as 12·8 per cent. TiO_2, show a concentration of titanium in comparison with the general titanium average of the upper lithosphere, which is 0·8 per cent. TiO_2. In the average composition of igneous rocks and sediments, the percentage by weight of Fe_2O_3 exceeds the percentage by weight of TiO_2, but in the residual clays and related materials, the percentage of TiO_2 may approach or exceed the percentage of Fe_2O_3. Amongst the typical analyses listed by Pettijohn ([10] *p.* 283) this relation obtains in a residual clay from basalt, in a diaspore clay, and in a plastic Ione clay.

From the considerable number of occurrences of sillimanite-bearing rocks in the Pella area an aluminous horizon in the original sediments may be postulated. However, in view of the limited size and, in particular, the limited persistence along the strike of most of the sillimanite bodies, it appears more likely that local accumulation of alumina-rich materials must already have existed along this horizon within the original sediments when metamorphism was commenced.

F. ECONOMIC POTENTIAL OF THE DEPOSITS

1. ACCESSIBILITY

The location of the Gamsberg is remote. The nearest railheads at Kakamas and Bitterfontein are 117 miles and 191 miles away respectively. The distance by road to Port Nolloth is 172 miles, and by rail from Bitterfontein to Cape Town 289 miles. The distance from Kakamas to Luderitz Bay is 534 miles by rail.

If a road were to be constructed to the deposits in the basin of the Gamsberg, it would have to pass either over the precipitous slopes at the periphery of the mountain, which is about 800 feet high or, through the northern gorge. The latter is a deeply incised narrow ravine with an extremely uneven rocky floor, and it is subject to periodic wash-aways. Road construction would therefore be expensive.

The sillimanite ore would be cheaper to transport, since it lies at the foot of the mountain.

2. IRON ORE

(*a*) *Manganiferous Iron Ore*

Although it is difficult to give a general specification entirely satisfactory for all applications of manganese ore consumption, the specification recently laid down by the Army and Navy Munitions Board of the United States ([1] *pp.* 111–7) is as follows:—

Mn (minimum)	40·00 per cent.
Fe (maximum)	14·00 per cent.
Mn:Fe ratio (minimum)	3·50
$SiO_2+Al_2O_3$ (maximum)	15·00 per cent.
P (maximum)	0·18 per cent.
Cu+Pb+Zn (maximum)	0·50 per cent.

A purer manganese ore is required for the production of standard-grade ferromanganese, and for the manufacture of battery cells. As a source of manganese the exposed ore in the Gamsberg is not of commercial quality, since the highest grade found in fourteen groove samples is as follows:—

Mn	25·13 per cent.
Fe	24·39 per cent.
Mn:Fe ratio	1·03
$SiO_2+Al_2O_3$	21·19 per cent.
P	0·15 per cent.

(*b*) *Hematite*

The hematite is of high grade, and the average of two representative samples indicates 63·37 per cent. metallic iron, 0·11 per cent. phosphorus, 0·39 per cent. sulphur, and 2·46 per cent. silica plus alumina.

The quantity of ore in the two exposed bodies is however extremely small. If the bodies do not pinch and swell appreciably in depth, the reserve is estimated at 33,000 tons (of 2,000 pounds) over an intercept of 50 feet down the dip.

3. BARITE

(*a*) *Specifications for Barite*

The physical and chemical specifications for barite vary according to use, and are quoted below ([2] *p.* 90).

" In *well-drilling muds* the material.........must be heavy and inert. Grinders attempt to produce a material of minimum 92 per cent. $BaSO_4$ free of soluble salts, such as calcium sulphate. Most grinders of well-drilling barite guarantee 90 to 95 per cent. passing 325-mesh, and a specific gravity of not less than 4·2. Several per cent. of iron oxide is not objectionable.

" For *chemical purposes*, a minimum of 94 percent $BaSO_4$ is generally specified with a maximum of 1 percent Fe_2O_3; a maximum of 1 percent strontium sulphate, with only a trace of fluorine permissible. Strontium sulphate in material intended for lithopone use may be somewhat higher. Mesh size is important to most consumers for chemical purposes; too fine a material results in dust loss, and too coarse a material results in poor mixing with powdered carbonaceous materials. Most consumers specify a material in the range 4- to 20-mesh; however, some consumers grind lump to this specification.

" *Glassmakers* have a specification usually requiring a minimum of 98 per cent $BaSO_4$, maximum SiO_2 1·5, Al_2O_3 0.15, and Fe_2O_3 0·15 per cent. In mesh size they prefer a mixture ranging from 30-mesh down through 140. Material ground to as fine as 325-mesh is not desirable, because of its tendency to ball up in the batch, but in times of short supply even this has been used. The most objectionable impurity is iron.

" Specfications for *filler and aggregate* are not so strict, and in most instances mesh size is most important."

(*d*) *Reserves*

The barite body outcrops more or less continously along a strike of 8,300 feet. The topography of the terrain is such that an extension of the body down the dip for at least a hundred feet can be interpolated.

If the body is continuous, and its average corrected thickness is taken at 28 feet, about 3,100,000 tons of barite would become available from every 100 feet of mining down the dip.

(*c*) *Utilisation*

The untreated barite ore would probably conform in bulk to the specifications for well-drilling muds. If selective mining and sorting were applied perhaps one-quarter of the ore could be realised in a purer grade which would be suitable for chemical purposes. Little, if any, of the barite could be used in the glass industry, or for purposes which require a dead-white powder, since even the purest sample obtained assayed more than 0·5 per cent. of ferric oxide. In this sample the ferric oxide does not merely form a surface stain, but is derived from small idioblasts of iron ore within the larger barite crystals. Whereas stains may be confined to the upper part of the deposit, the idioblasts are likely to continue in depth as well.

Beneficiation of the ore could undoubtedly be effected, but wet-treatment on the site or elsewhere on the farm would depend on water-supply. In this area a successful bore-hole for water could at best not be expected to yield more than 1,000 gallons per hour, and the possibility of exhaustion is great.

4. SILLIMANITE

There are no exact chemical specifications from which can be decided when ores of the sillimanite group (which includes the trimorphous minerals andalusite, sillimanite, and kyanite), are suitable for the manufacture of refractories. In general the minerals should contain as little fusible impurities such as iron, lime, magnesia, and alkalis as possible. To evaluate the ore, bulk samples are required, and data must be determined on test-bars (to observe load-bearing properties at high temperatures); on cones of the powdered ore (to determine refractoriness); and on briquettes (for the measurement of shrinkage, porosity, absorption, and spalling).

The sillimanite of the northern lens is not of economic value. The analysed sample contains 55·6 per cent. Al_2O_3, as compared with 63·2 per cent., Al_2O_3 for pure sillimanite. It also contains 2·7 per cent. Fe_2O_3, which for certain purposes, e.g. the manufacture of electrical porcelain, must not exceed 0·2 per cent.

The southern sillimanite body may be of economic value. The percetages of Al_2O_3, Fe_2O_3, TiO_2, MgO, and CaO, in the analysed specimen are less favourable than the amounts of these radicals in the analyses which are quoted of bulk samples from deposits which are being exploited on Wortel and Koenabib (cf. table No. 5, analyses II, V, VI, and VII). The reserves of float-ore, and of ore in situ (to a depth of 10 feet), is of the order of 2,000 tons.

5. CONCLUSIONS

At least 3,000,000 tons of barite exist in a deposit on the farm Gams (portion 1) in the District of Namaqualand. Since the barite contains an appreciable amount of ferric oxide, it is only suitable for use in the production of well-drilling muds, and for chemical purposes. The remoteness of the site, and the low price of the product, would render exploitation under present conditions unprofitable.

One of the sillimanite deposits on the same farm has a reserve in sight of about 2,000 tons, and may be of a grade which is suitable for the manufacture of refractories. It would be impossible, however, to negotiate a contract for material of this quality, unless the quantity can be supplemented by similar ore from other occurrences in the neighbourhood.

The successful exploitation of the other ore-bodies is impossible on account of the inferior quality of the manganiferous ore, the extremely small quantity of high-grade hematite ore, and the remote location of the deposits.

OPSOMMING IN AFRIKAANS

MANGAANHOUDENDE YSTERERTS, HEMATIET, BARIET, EN SILLIMATIET OP GAMS (GEDEELTE I), NAMAKWALAND

deur

C. B. Coetzee

I.—ALGEMENE GEOLOGIE

Afsettings van mangaanhoudende ystererts, hematiet, bariet, en sillimaniet kom in die Gamsberg voor, op die plaas Gams (Gedeelte 1), wat 30 myl wes van Pofadder, in die Distrik Namakwaland, geleë is.

Die kruin van die Gamsberg is 'n erosierelik van 'n ou skeirvlakte ([8] *pp.* 13–15), en bereik 'n hoogte van meer as 800 voet bokant die algemene elevasie van die omliggende sandvlakte. Die oppervlak van die sentrale gedeelte van die Gamsberg daal skerp en vorm 'n niervormige kom waarvan die vloer min of meer gelyk is en 200 tot 250 voet benede die hoogte van van die tafelland lê.

Die Gamsberg is saamgestel uit metamorfe sedimente wat tot die Serie Kaiing van die Sisteem Kheis behoort. Die boonste gedeelte van die metamorfe sedimente bestaan uit kwartsiet en kwarts-serisiestkis, terwyl die onderste gedeelte uit kwarts-biotietskis, kwarts-sillimanietskis, en amfiboliet bestaan. Hierdie gesteentes vorm dakhangers in 'n onderliggende massa van jonger aplograniet ([4] *pp.* 181-189), wat ook as gegranitiseerde sedimente vertolk kan word ([11] *pp.* 450–470).

Die grootskaalse struktuur van die Gamsberg kom ooreen met 'n dubbelduikende antiklien wat plek-plek plooiing in die vleuels toon. Die kam van die antiklien was bokant die teenswoordige kom, en omdat die kam uit kompetente kwartsiet saamgestel was, was dit waarskynlik baie gebroke en minder as die vleuels teen verwering bestand. Detritus is gevolglik van die kam weggevoer, en uiteindelik het 'n kom in die sagte kern van die atiklien ontwikkel.

II. ERTSAFSETTINGS.

Afsettings van mangaanhoudende ystererts, en bariet kom op, of naby, die kontak van die geherkristalliseerde kwartsiet en die kwarts-biotietskis voor, omtrent 100 voet bokant die vloer van die kom. Die bariet word sowat 30 voet vertikaal benede die ysterertse aangetref. Hoewel die ertsliggaam saamgesteld is, is die ertse nie op 'n megaskopiese skaal vermeng nie, maar word as aparte lense en tafelvormige plate aangetref wat naas mekaar lê. Die ertse het 'n koepelhelling van 30° tot 60°, en hul voortsetting in diepte is blykbaar nooit parallel aan die laagvlakhang van die kom nie.

Twee lense van massiewe sillimaniet word laag af in die metamorf Kaiinggesteentes aan die voet van die Gamsberg gevind, sowat 7,000 voet suidoos van die bariet- en ysterertsafsettings.

A. DIE MANGAANHOUDENDE YSTERERTSAFSETTING

Hierdie afsetting is by lokaliteite 1, 5, 7, 8, 9, en 10 in die vorm van aparte ligaanpies blootgelê; die totale lengte van die onderbroke mineralisasie langs die strekking is 26,000 voet tussen lokaliteite 1 en 10 (vgl. voublad). Die dakkant van die erts is kwartsiet, en die vloerkant is kwartsiet of skis.

Die volgende ertsminerale is in ses van die monsters bepaal: jakobsiet, kriptomelaan, bixbyiet, psilomelaan, pirolusiet, en hematiet. Die aarsteenminerale in die erts van lokaliteit 5 is, in orde van die hoeveelhede waarin hulle voorkom, die volgende: ortopirokseen, klinopirokseen, granaat, kwarts, en mikroklien.

'n Aantal analises van die groefmonsters wat by die verskillende lokaliteite geneem is, toon dat die hoogste mangaaninhoud 25·13 persent is en die verhouding van Mn tot Fe sowat 1. Silika en alumina is saam 21·19, en daar is 0·15 persent fosfor.

B. DIE HEMATIETAFSETTING

Twee hoëgraadse hematietliggaampies word by lokaliteite 1 en 6 op die strekking van die mangaanhoudende ysterertsafsetting aangetref. Die gemiddelde van twee tipiese monsters toon 63·37 persent yster, 0·11 persent fosfor, 0·30 persent swael, en 2·46 persent silika plus alumina.

C. DIE BARIETAFSETTING

Die barietplaat is met tussenposes oor 'n strekking van 8,300 voet blootgelê, en dit het moontlik 'n gemiddelde vertikale dikte van 28 voet. Die dakkant van die erts is kwartsiet, en die vloerkant is skis of kwartsiet met skislense.

Die bariet bevat wisselende hoeveelhede ferrioksied, en die volgende kleure in orde van die hoeveelheid waarin hulle voorkom, word aangetref: grys, ligrooi, rooierig, en wit. Die skoner (wit) bariet word as afsonderlike bande en potte in die ander tipes aangetref, maar is soms ook met hulle vermeng.

Chemiese analises van die bariet toon dat die persentasie van $BaSO_4$ wissel van 85·18 (abnormaal laag) tot 98·27, die van Fe_2O_3 van 0·64 tot 8·47 en die van SiO_2 van 1·09 tot 8·25.

D. DIE SILLIMANIETAFSETTINGS

Die noordelike voorkoms het 'n onderbroke strekkingslengte van 640 voet, en 'n gemiddelde dikte van omtrent 18 duim. Die suidelike voorkoms is waarskynlik lensvormig: dit is nagenoeg 100 voet lank, en omtrent 30 voet dik naby die middelpunt. Die afsettings word in mikahoudende skis aangetref aan die teenoorgestelde kante van 'n kwartsietkoppie.

Chemiese analises van die sillimaniet toon dat veral die materiaal van die suidelike voorkoms, met 58·78 persent Al_2O_3, baie gunstig met die van Wortel en Koenabib, waar sillimaniet gedelf word, vergelyk.

E. ONTSTAAN VAN DIE AFSETTINGS

1. DIE BARIET EN YSTERERTSAFSETTINGS

Die feit dat die afsettings saam voorkom en die samestelling van die ertse self dui op 'n gelyksoortige ontstaan vir albei. Die veldverhoudings, die petrografie, en die gevolgtrekkings van Mathias ([9] *pp.* 208–217) in verband met die voorkoms van bariet in 'n ysterertsafsetting tien myl noord-noordwes van die Gamsberg, suggereer 'n epigenitiese oorsprong. Nadat die afsettings gevorm het, is hulle aan termale metamorfose blootgestel.

2. DIE SILLIMANIETAFSETTINGS

Die ontstaan van die sillimaniet moet benader word in die lig van die navorsingswerk van Coetzee ([3] *pp.* 201–204) en Wiid ([14] *pp.* 4–6) op die sillimaniet-korundgesteente naby Pella, asook van die groot aantal chemiese analises wat van massiewe sillimaniet van Wortel en Koenabib vir mnr. R. G. Niemoller gemaak is. Plaaslike versamelings van aluminaryke materriaal word in die oorspronklike Kaiingsedimente gepostuleer voordat metamorfose begin het.

F. EKONOMIESE POTENSIAAL VAN DIE AFSETTINGS

Die ontginning van die afsettings word aan bande gelê deur die huidige pryse van die produkte, hul afsondering, en die ruwe terrein van die Gamsberg. Die sillimanieterts sal goedkoper wees om te vervoer omdat dit aan die voet van die berg lê.

Die blootgestelde mangaanhoudende ystererts is ongeskik as 'n bron van mangaan omdat die hoogste gehalte wat deur veertien ontledings aangetoon word, slegs 25·1 persent mangaan bevat, wat veel minder is as die minimum van 40·0 persent mangaan wat in die handel vereis word. Die hematiet is van hoë graad, maar die beraamde reserwe (d.w.s. omtrent 33,000 ton van 2,000 pond tot 'n diepte van 50 voet langs die helling) is te klein en die vervoerkoste te hoog om ekonomiese ontginning moontlik te maak.

Indien die barietliggaam aaneenlopend is langs die strekking en in diepte, kan nagenoeg 3,100,000 ton erts herwin word uit elke honderd voet wat langs die helling gedelf word. Tensy die bariet gebenefisieer word, is dit waarskynlik alleen geskik vir die bereiding van boormodder ([2] *p.* 90). Die prys van bariet vir die doel is egter die laagste van die grade waarin bariet bemark word, en is tans ontoereikend om ontginning te regverdig.

Die sillimaniet van die noordelike lens is ondergraads. Die suidelike liggaam het 'n reserwe in sig van omtrent 2,000 ton, en die gehalte is moontlik geskik vir die bereiding van vuurvaste stowwe. Tensy die hoeveelheid egter aangevul kan word met dergelike erts wat uit ander voorkomste verkry kan word, is dit twyfelagtig of 'n kontrak vir die lewering daarvan gesluit sal kan word.

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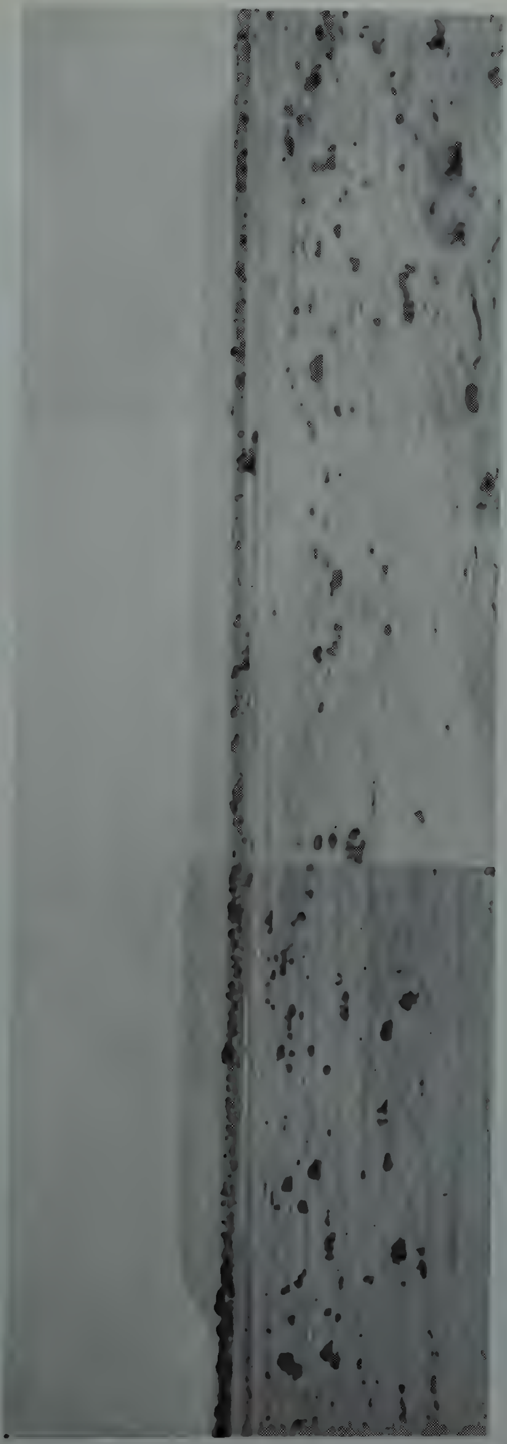
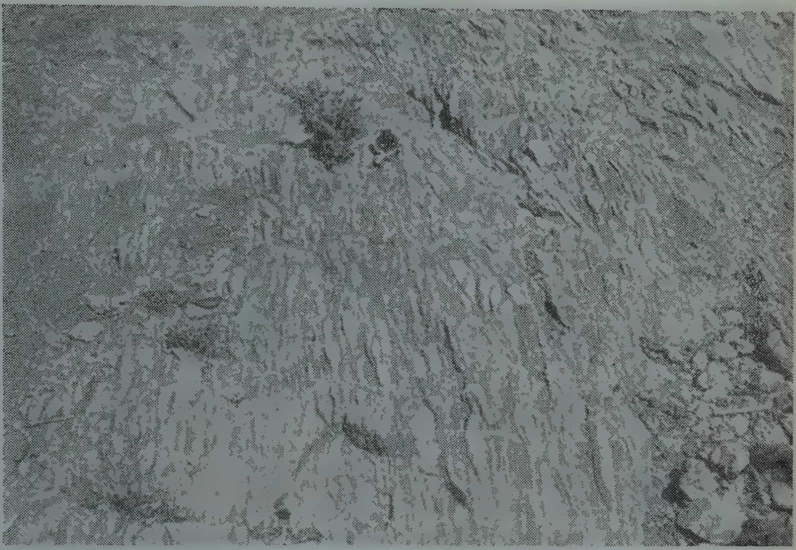


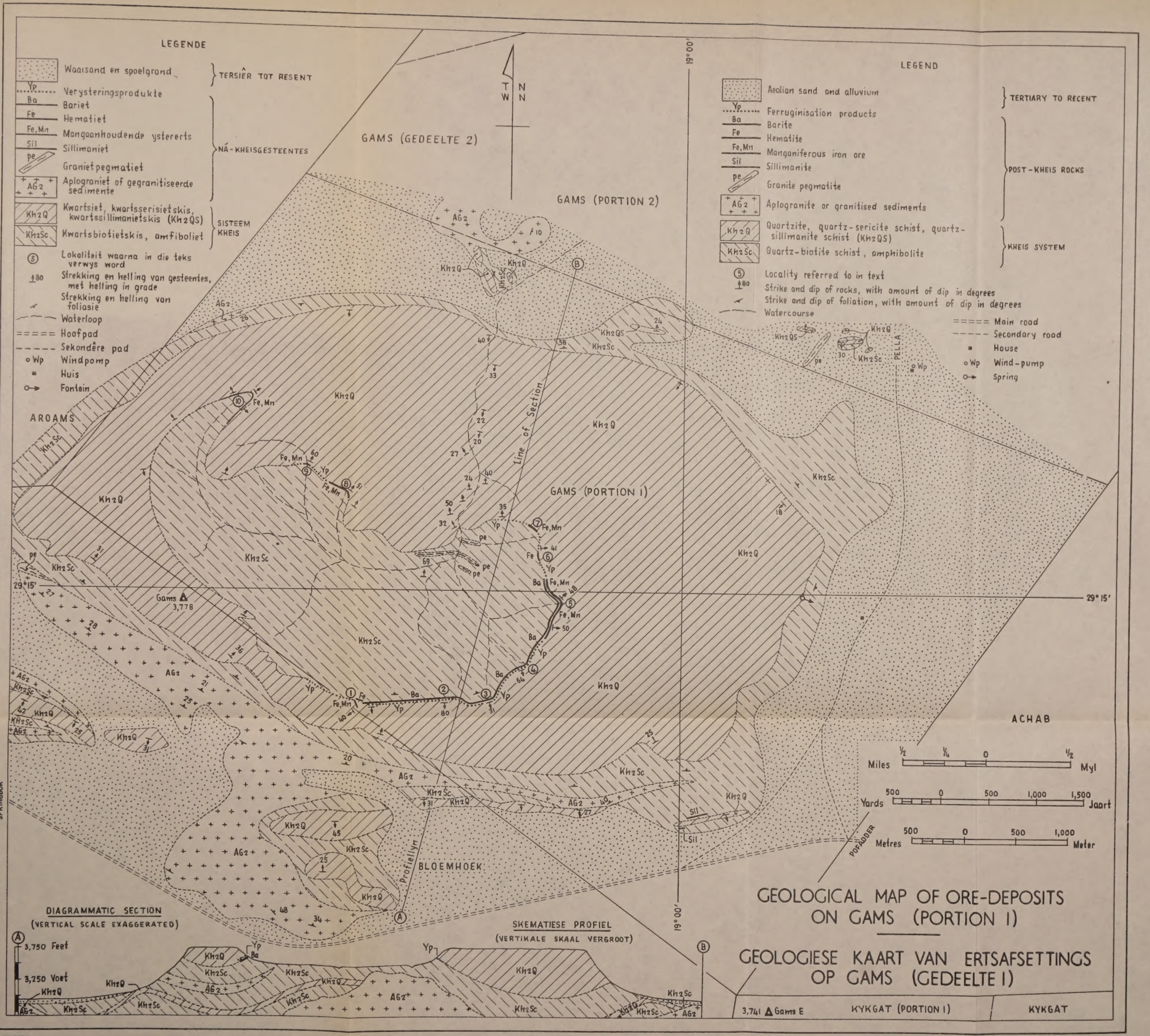
I.—Panoramic view of the northern flank of the Gamsberg from a distance of 5 miles.

II.—View of the southern flank of the Gamsberg showing cliffs of Kaaien quartzite at the top, slopes of biotite schist lower down, and cliffs of granitic rocks near the base. The basin is most readily approached from the south along this indentation in the girdle of cliffs and precipitous slopes.

III.—The inside of the basin showing ravines opposite localities 8 and 9



IV.—Deformed pebbles and cobbles in quartz-biotite schist on the floor of the basin


LEGENDE
Waaisand en spoelgrond
TERSIÊR TOT RESENT
Yp Verysteringsprodukte
Ba Bariet
Fe Hematiet
Fe,Mn Mangaanhoudende ystererts
Sil Sillimaniet
pe Granietpegmatiet
AG2 Aplograniet of gegranitiseerde sedimente
NÁ-KHEISGESTEENTES
Kh2Q Kwartsiet, kwartsserisietskis, kwartssillimanietskis (Kh2QS)
Kh2Sc Kwartsbiotietskis, amfiboliet
SISTEEM KHEIS
⑤ Lokaliteit waarna in die teks verwys word
80 Strekking en helling van gesteentes, met helling in grade
Strekking en helling van foliasie
Waterloop
Hoofpad
Sekondêre pad
Wp Windpomp
Huis
Fontein
LEGEND
Aeolian sand and alluvium
TERTIARY TO RECENT
Yp Ferruginisation products
Ba Barite
Fe Hematite
Fe,Mn Manganiferous iron ore
Sil Sillimanite
pe Granite pegmatite
AG2 Aplogranite or granitised sediments
POST-KHEIS ROCKS
Kh2Q Quartzite, quartz-sericite schist, quartz-sillimanite schist (Kh2QS)
Kh2Sc Quartz-biotite schist, amphibolite
KHEIS SYSTEM
⑤ Locality referred to in text
80 Strike and dip of rocks, with amount of dip in degrees
Strike and dip of foliation, with amount of dip in degrees
Watercourse
Main road
Secondary road
House
Wp Wind-pump
Spring
T N
W N
GAMS (GEDEELTE 2)
GAMS (PORTION 2)
GAMS (PORTION I)
AROAMS
ACHAB
BLOEMHOEK
PELLA
SPRINGBOK
POFADDER
Line of Section
Profiellyn
19°00'
29°15'
Gams 3,778
Kh2Q
Kh2Sc
Kh2QS
AG2
Fe,Mn
Ba
Yp
pe
Sil
①
②
③
④
⑤
⑥
⑦
⑧
⑨
⑩
Ⓐ
Ⓑ
Miles ½ ¼ 0 ½ Myl
Yards 500 0 500 1,000 1,500 Jaart
Metres 500 0 500 1,000 Meter
DIAGRAMMATIC SECTION
(VERTICAL SCALE EXAGGERATED)
SKEMATIESE PROFIEL
(VERTIKALE SKAAL VERGROOT)
3,750 Feet
3,250 Voet
3,741 Gams E
KYKGAT (PORTION I)
KYKGAT

GEOLOGICAL MAP OF ORE-DEPOSITS ON GAMS (PORTION I)

GEOLOGIESE KAART VAN ERTSAFSETTINGS OP GAMS (GEDEELTE I)

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